

Not that Again! : Recurring findings from the commissioning of green buildings.

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Synopsis

In the past five years CTG Energetics, Inc. of Irvine, California has provided building systems commissioning services for new construction of over a dozen high-performance, energy efficient, and green buildings --- most pursuing certification under the US Green Building Council's LEED-NC rating system. Although every owner, design team, building, and project is unique, our experience indicates that several project management and technical problems recur consistently in new construction of green building and LEED projects.

CTG's short-list of recurring problems in commissioning green buildings includes:

- Ownership commitment is key to commissioning success;
- Unmanageable complexity in building systems should be avoided - at all costs;
- Appropriate sequences of operation are often ambiguous (or non-existent);
- Daylight dimming control systems require significant design and field coordination;
- Underfloor air delivery plenums are difficult to seal for control of supply air;

This paper addresses these and other issues that we find consistently emerge in commissioning of LEED-NC and green building projects, as a cautionary tale for commercial building owners, designers, builders, and commissioning providers.

About the Authors

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Introduction

Since the US Green Building Council released the Leadership in Energy and Environmental Design for New Construction (LEED-NC) Green Building Rating System in 2000, CTG Energetics, Inc. (CTG) of Irvine, CA, has served as the commissioning authority for ten LEED-NC certified projects including three projects certified at the “Platinum” level. CTG is in the process of providing commissioning to approximately twenty additional projects pursuing LEED certification.

In our experience, the requirements of LEED projects (particularly those pursuing Gold and Platinum certification), which often include non-standard mechanical, electrical, and plumbing systems, significantly increase the amount of effort required for commissioning a project; however, LEED certification also commensurately multiplies the resulting benefits of commissioning and is, therefore, well worth the extra effort it takes to reach the certification.

This paper discusses five ‘lessons learned’ from CTG’s experience providing commissioning services to LEED-NC projects, specifically:

- The commitment the Owner(s) is the key to commissioning success
- Unmanageable complexity in building systems should be avoided - at all costs!
- The sequence of operational tasks is often ambiguous
- Daylight dimming systems require significant coordination
- Underfloor air delivery plenums are difficult to seal for supply air control

Both the LEED-NC rating system and the building commissioning industry must continue to evolve as increasing numbers of LEED projects shed new light on the practical, technical, economic, and environmental issues associated with commissioning.

LEED, Green Buildings, and Commissioning

In March 2000, the US Green Building Council (USGBC) released the first public version of its LEED™ Green Building Rating System. As of May 2004, the LEED rating system has been updated and relabeled as LEED for New Construction (LEED-NC) version 2.1, with a further update, version 2.2, slated to take effect in the Fall of 2005.

USGBC describes the purpose and intent of LEED as:

“The Leadership in Energy and Environmental Design (LEED™) Green Building Rating System represents the U.S. Green Building Council’s effort to provide a national standard for what constitutes a “green building.” Through its use as a design guideline and third-party certification tool, it aims to improve occupant well-being, environmental performance and economic returns of buildings using established and innovative practices, standards and technologies.”

Over the last five years, LEED has experienced significant market penetration for new commercial construction in the United States. As of February 2005, there are over 160 LEED certified projects and more than 2,000 registered projects, throughout the country, pursuing LEED certification.

The LEED-NC, v2.1 rating system includes seven prerequisites and 69 available points. As a prerequisite, 'Fundamental Building Systems Commissioning' is required for all LEED projects, while one point is also available for 'Additional Commissioning'. Providing overall guidance as well as some specific requirements concerning 'Fundamental' and 'Additional' commissioning, the LEED rating system also allows for a broad array of approaches and activities related to commissioning different types of systems and facilities.

LEED has been designed to be competitive in nature, awarding various levels of certification to projects that achieve all seven LEED prerequisites along with increasing numbers of LEED points:

- Certified (26 to 32 points)
- Silver (33 to 38)
- Gold (39 to 51)
- Platinum (52 or more)

LEED Gold and Platinum Projects

As of February 2005, there are eighteen buildings in California that have been awarded a LEED-NC rating, and CTG Energetics, Inc. (CTG) has served as the commissioning authority for ten of these facilities, including six projects that have achieved a LEED 'Gold' or 'Platinum' certification:

- The William and Flora Hewlett Foundation - Menlo Park, CA; LEED Gold (43 Points) awarded September 2002;
- Toyota Motor Sales South Campus Office Development – Torrance, CA; LEED Gold (47 Points) awarded April 2003;
- Audubon Center at Debs Park – East Los Angeles, CA; LEED Platinum (53 Points) awarded December 2003;
- Hayward Building Systems Plant – Santa Maria, CA; LEED Gold (40 Points) awarded January 2003;
- Inland Empire Utility Agency (IEUA) Administrative Headquarters – Chino, CA; LEED Platinum (52 Points) awarded March 2004;
- Natural Resources Defense Council (NRDC) Robert Redford Building – Santa Monica, CA; LEED Platinum (55 Points) awarded May 2004.

In CTG's experience as consultants and/or commissioning authority for over 50 LEED certified and registered projects, many projects can achieve a LEED 'Certified' or 'Silver' rating through commitment and diligence in the design, specifications, and construction practices, but without installing particularly innovative or unique building systems. LEED projects that strive for

‘Gold’ or ‘Platinum’ ratings, however, typically include advanced MEP systems that support energy, environmental and LEED objectives of the facilities, and allow the projects to achieve increasing numbers of LEED points.

For example, all six of the LEED Gold and Platinum projects cited above include roof-mounted photovoltaic power systems. Four of these projects include waste water and/or storm water treatment and reclamation systems. Three of these facilities include low-energy HVAC systems that we would consider to be fairly innovative and unique for the type of facility served.

The USGBC included Fundamental Building Systems Commissioning as a requirement for LEED certification in order to ensure that LEED projects will benefit from the enhanced quality control associated with building commissioning. Innovative MEP systems often heighten both the effort required and the relevance of building system commissioning, since the owners, designers, and installers (and even perhaps the commissioning authority) are often unfamiliar with the innovative MEP system applications.

Recurring Findings

There are numerous recurring findings or ‘lessons learned’ from CTG’s experiences to date commissioning LEED-NC buildings. With each new project, we encounter unique technical, project management, and administrative issues that expand our knowledge and influence our approach to building systems commissioning. The six lessons learned presented in this paper are more anecdotal than empirical. We have found that much of value that results from the commissioning process is quite project-specific. Further, the added value of building commissioning is difficult to quantify and analyze in a statistically rigorous way across a range of different projects, which include unique systems, deficiencies, and resolutions.

Ownership Commitment is Key to Commissioning Success;

Commissioning (with its goal of identifying and correcting errors, omissions, and deficiencies in the design and construction of building systems) can devolve into a contentious and adversarial process. On most construction projects, the designers and contractors must cope with schedule and budget constraints that do not allow additional time or resources for correcting unforeseen system deficiencies. In certain projects, this puts the commissioning authority in a difficult position of identifying problems that must be resolved by others, and certainly there can be a tendency to want to shoot the messenger.

The owner’s commitment to the commissioning process (as well as to the greater process of LEED certification) is essential to its success. It is much easier for design professionals and contractors to disregard the commissioning process, and any problems revealed, if the owner is disengaged from, or unsupportive of the commissioning process.

Unfortunately, even for projects pursuing LEED certification, certain building owners remain disengaged from commissioning activities. Although commissioning is a LEED requirement, in CTG’s experience some owners embrace LEED without fully embracing the value of building systems commissioning. Many owners struggle to define a set of Owner’s Project Requirements (i.e. Design Intent Document) beyond setting a firm expectation for LEED certification.

Commissioning can even be seen as an impediment to achieving LEED certification because it is one of the last LEED-related activities to be completed and documented prior to submitting an application for LEED certification. During the phase of construction when much of the commissioning related testing occurs, the primary concern for some owners is completing construction and submitting the application for LEED certification as quickly as possible, while avoiding any additional costs.

CTG has performed commissioning services for LEED projects where significant system deficiencies, including non-functioning HVAC systems, were left unresolved, by the owners' choice, in an effort to 'finish' and occupy the facility prior to a particular owner deadline – such as scheduled grand opening celebrations.

Fortunately, the majority of our clients value and support the commissioning process, including providing additional time (and fees) to resolve system deficiencies discovered through commissioning. In our experience, the commissioning process always yields long term benefits to the owner, in terms of better performing, easier to maintain and more efficient systems, even when correcting deficiencies leads to near-term construction delays or contractor change-orders.

Unmanageable complexity in building systems should be avoided

Many LEED and green buildings include energy using systems that CTG would label as “unmanageably complex”. In an effort to reduce energy use, improve comfort, and optimize indoor air quality while providing abundant system flexibility and opportunity for user controls, many green buildings include systems that are innovative but not well understood by the installers, building operators, and users.

Owners and designers' enthusiasm to develop a green building can cloud professional judgment and result in system designs which are untested, difficult to construct, and beyond the comprehension of the building occupants and operators. CTG has observed innovative HVAC systems, renewable energy systems, and waste water treatment systems that will never achieve their intended performance due to a sheer lack of understanding by the facility personnel of how to operate the system. Although training and O&M documentation can assist facility staff in operating and maintaining unique and innovative system designs --- if the engineering solutions of a building far exceed the sophistication of the installers or operators, significant deficiencies are inevitable. We find this problem most often in small facilities where the “facility manager” is likely to be an administrative office manager with little or no mechanical background or training in building systems.

As an independent commissioning authority, with no direct responsibility for system design, we find that we often have some opportunity to assist projects in avoiding unnecessary and unmanageable complexity. The commissioning authority should provide design reviews (a LEED requirement for 'Additional Commissioning') and may be able to steer the designers away from overly complex design solutions that are likely to yield significant problems during installation, commissioning, and/or operations. Another significant opportunity for the

commissioning authority to address undue complexity in building systems is by ensuring that appropriate O&M documentation and training are provided.

Sequences of operation are often ambiguous

Clear and detailed sequences of operation are essential to the proper operation of building MEP systems. In CTG's experience, sequences of operation are often inadequately developed or documented by the designers and the system installers, and are often poorly understood by building operators. CTG has witnessed many existing buildings where major building systems are operated manually, or where much of the intended functionality of the MEP systems has been disabled, resulting from poor documentation or understanding of the intended sequences of operation.

Even in high performance green buildings, sequences of operation for MEP systems are sometimes not well documented by the designers and installers. Often, with little or no information provided, the controls contractor develops sequences of operation in the field during the system start-up and control system programming. This situation can be particularly problematic for innovative and non-standard systems where the controls contractor may not understand or have experience with the installed system or the designer's intent. Further, sequences of operation developed in the field are not typically well documented.

Incomplete and ambiguous written sequences of operation make it difficult for the commissioning agent to develop testing procedures. CTG recommends that design teams issue a detailed written sequence of operation for each active system, and that the controls contractor prepares 'red-lines' of this document highlighting any changes made during the actual programming, start-up, testing, and fine tuning of the systems. This will serve as a valuable record for the building operations staff, as valuable as the as-built record drawings.

Daylight dimming systems require significant coordination;

Sophisticated lighting controls, and in particular automated daylight responsive dimming systems, are often recommended, specified, and installed in LEED buildings. Used to verify and document up to 10 LEED-NC points for Energy & Atmosphere Credit 1 'Optimizing Energy Efficiency', software-based building energy simulations typically assign great energy efficiency value to automated daylight dimming systems. These software simulations assume lighting control systems operate as intended, and do not take into account real world design, installation, or operator errors which may degrade system performance.

In our experience, the performance of automated daylight responsive lighting controls is extremely sensitive to photocell location, system calibration, zoning/circuiting issues, as well as to occupant preferences. Most lighting designers, electrical contractors, and building operators do not have enough experience with automated daylight dimming systems to appreciate the complexity of hardware, controls, and human factors that dictate whether the system will operate as intended. Automated daylight dimming systems are intended to dim the electrical lighting in

response to ambient daylight in order to maintain predetermined illumination levels at task level. However, in our experience, many of these systems never work properly.

As an example, one automated daylight dimming system (which includes significant daylight penetration through windows and skylights) failed to respond at all to changing levels of ambient daylight. Commissioning revealed that this was due to the location of the photocell sensors, in relatively dark locations, were unaffected by changes in daylight. The nuances of daylight availability in different locations can be extremely difficult to predict during the design process, when the photocell sensor locations are typically determined. In the example case, CTG recommended that the photo sensors be relocated approximately five feet away that experienced greater influence from changing daylight levels in order to yield the intended system response.

Occupancy sensor lighting controls are also sensitive to issues related to location and calibration. In many buildings, CTG finds that occupancy sensors are too sensitive – bringing on lights in an office when someone passes in the adjacent corridor; meanwhile, other occupancy sensors are not sensitive enough, due to calibration and/or location – turning lights off in restrooms when someone is present due to a sensor location that cannot ‘see’ past the restroom partitions.

Proper adjustment of occupancy sensor often cannot be performed until after the installation of the furniture and furniture systems. The lighting installer (or possibly the Commissioning Authority) waiting for the furniture installation to tune occupancy sensors presents a construction coordination and phasing issue that typically is not accounted for in the project budget or schedule.

Our experience has shown that automated daylight dimming control sensors and occupancy sensors require significant field coordination and calibration to operate as intended. We have seen the greatest success with these lighting controls when the lighting designers, installing contractors, manufacturers’ technical representatives and building operations staff work collaboratively in the field to fine tune the location and calibration of all lighting controls devices and systems.

Underfloor air delivery plenums are difficult to seal for control of supply air;

Underfloor air distribution systems are prevalent in green buildings since they provide improved occupant control, indoor air quality, and energy efficiency compared to more conventional overhead air distribution. CTG has provided commissioning authority services for several green buildings employing underfloor air distribution systems. We have found that underfloor air plenums rarely (if ever) provide the desired control of air distribution since creating tight air seals at all floor seams and edges is near impossible.

Conceptually, underfloor air distribution systems are relatively open, low pressure plenums that provide even air distribution across a large area. In reality we have found underfloor air plenums are not adequately sealed and that the plenum often becomes constricted with ductwork and cabling. The result is that air flow is rarely as evenly distributed as designers hoped and

intended. Floor diffusers that are remote from the supply air inlet are often starved, while diffusers near the supply air inlet have too much flow.

Further, it is extremely difficult to perform a conventional HVAC diffuser air balance in an underfloor air distribution system. If an underfloor air diffuser is starved for air, it is unlikely that simply reducing air flow to other diffusers in that zone will balance the system. Closing off diffusers generally results in more local air “leakage” through the floor seams, rather than diverting supply air to diffusers in other areas of the supply air plenum.

Variable Air Volume delivery for underfloor air plenums is also problematic to control, depending on if or how pressure in the underfloor plenum is measured and controlled. Given the low pressure under the plenum, opening and closing operable windows, opening and closing doors, and starting underfloor fan terminal units yield small but significant plenum pressure changes that wreak havoc on VAV control schemes tied to plenum pressure.

Conclusions

The building industry has relatively little experience to date with the LEED rating system and with commissioning for green buildings. Most, if not all, building owners, design professionals, consultants, and contractors are still learning about the nuances of building system commissioning while developing better processes for implementing both LEED and commissioning. As a commissioning authority and consultant to numerous LEED projects, CTG continues to learn from each project and evolve our services to meet the needs of green building projects.

It is important that the building industry openly address and discuss practical, technical, economic, and environmental concerns associated with construction in general and the LEED rating system, and the building systems commissioning process in particular. This paper addresses what we believe are a few important lessons learned from commissioning LEED facilities. We hope that by sharing these lessons, CTG can contribute to a greater dialogue about LEED and commissioning, so that green building projects may continue to improve.